

2.4 Moisture analysis

WARNING

Make sure that the transformer is de-energized and out of service before any work is performed on the bushing.

This method for diagnostics can only be used on liquid filled bushings e.g. GOx types. Normally we do not recommend our customers to take oil samples from our bushings. The bushing is sealed and tightness tested at the time for the manufacturing. An oil sampling means that the bushing has to be opened. Thus, it is also a risk for improper sealing after the sampling is finished.

However, when a problem is known, for example high power factor over C_1 , there might be a need for oil sampling and moisture analysis.

To get the proper moisture content in bushing oil is sometimes difficult. Compared to a transformer, a bushing has a much higher ration of paper to oil. This means that regardless of the bushing manufacturing process, there will always be much more moisture in the paper than in the oil. (In paper the moisture is measured in %, whereas in oil the moisture content is measured in ppm, "parts per million".)

Depending on the temperature of the bushing, the moisture will move from the paper to the oil or from the oil to the paper, all given by the equilibrium curves (piper diagram) on oil-paper moisture. Due to this, a bushing will always show a much higher moisture content in the oil after a certain time in service a high temperature. Consequently, to get a proper value, the oil sample should be taken at least 48 hours after the entire bushing has reached room temperature.

2.4.1 Oil sampling from bushing

The oil sampling is performed similar as for DGA analysis.

2.4.2 Interpretation of the analysis

The bushing is delivered from ABB Components with a moisture content in the insulating oil of maximum 3 ppm. If considerably higher concentrations are measured the sealing system is damaged on the bushing.

At a concentration >10 ppm a tan δ measurement shall be performed according to section 2.1.2. Measures shall be taken according to the recommendation in section 2.1.3. At a concentration > 20 ppm the bushing shall be taken out of service.

2.5 Oil leakage inspection

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A visual inspection for leakage may be performed at normal station supervision.

2.6 Insulator inspection

2.6.1 Hydrophobicity classification

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The following information for hydrophobicity classification is with minor changes taken from STRI AB, Guide 1, 92/1 Hydrofobicity Classification Guide. STRI AB is an independent company for development and testing in the field of electrical power transmission and distribution. STRI is jointly owned by ABB, Svenska Kraftnät (the Swedish National Grid), Vattenfall AB and Statnett SF (the Norwegian National Grid).

2.6.1.1 General

The superior electrical performance of composite insulators and coated insulators stems from the hydrophobicity (water-repellency) of their surfaces. The hydrophobicity will change with time due to exposure to the outdoor environment and partial discharges (corona).

Seven classes of the hydrophobicity (HC 1-7) have been defined. HC 1 corresponds to a completely hydrophobic (water-repellent) surface and HC 7 to a completely hydrophilic (easily wetted) surface.

These classes provide a coarse value of the wetting status and are particularly suitable for a fast and easy check of insulators in the field.

2.6.1.2 Test equipment

The only equipment needed is a common spray bottle which can produce a fine mist (Fig. 8). The spray bottle is filled with tap water. The water shall not contain any chemicals, as detergents, tensides, solvents.

Complementary equipment which could facilitate the judgement are a magnification glass, a lamp, and a measuring-tape.

Fig. 8. Example of a suitable spray bottle for the test.

2.6.1.3 Test procedure

The test area should be 50-100 cm². If this requirement could not be met it should be noted in the test report.

Squeeze 1-2 times per second from a distance of 25 ± 10 cm. The spraying shall continue for 20-30 seconds. The judgement of the hydrophobicity class shall be performed within 10 seconds after the spraying has been finished.

The hydrophobicity classification could be difficult to perform in high winds. If such difficulties, or other, are present this should be noted in the test report.

2.6.1.4 Classification of the hydrofobicity

The actual wetting appearance on the insulator has to be identified with one of the seven hydrophobicity classes (HC), which is a value between 1 and 7. The criteria for the different classes are given in Table 4. Typical photos of surfaces with different wetting properties are shown in Fig. 10.

Also the contact angle (θ) between the water drops and the surface must be taken into account. The contact angle is defined in Fig. 9. There exist two different contact angles, the advancing contact angle (θ_a) and the receding contact angle (θ_r). A drop exhibits these angles on an inclined surface.

The receding angle is the most important when the wetting properties of an insulator shall be evaluated. The inclination angle of the surface affects the θ_r .

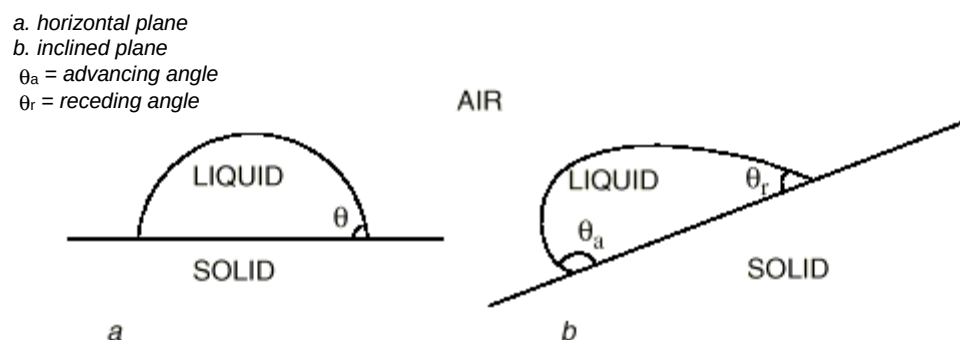


Fig. 9. Definition of contact angles.

Table 4. Criteria for the hydrophobicity classification (HC).

HC	Description
1	Only discrete droplets are formed. $\theta_r \gg 80^\circ$ or larger for the majority of droplets.
2	Only discrete droplets are formed. $50^\circ < \theta_r < 80^\circ$ for the majority of droplets.
3	Only discrete droplets are formed. $20^\circ < \theta_r < 50^\circ$ for the majority of droplets. Usually they are no longer circular.
4	Both discrete droplets and wetted traces from the water runnels are observed (i.e. $\theta_r = 0^\circ$). Completely wetted areas $< 2 \text{ cm}^2$. Together they cover $< 90 \%$ of the tested area.
5	Some completely wetted areas $> 2 \text{ cm}^2$, which cover $< 90 \%$ of the tested area.
6	Wetted areas cover $> 90 \%$, i.e. small unwetted areas (spots/ traces) are still observed.
7	Continuous water film over the whole tested area.